HEC-FDA

Hydrologic Engineering Center's Flood Damage Reduction Analysis Computer Program

HEC-FDA Purpose

- HEC-FDA is a computer program that allows you to formulate and evaluate flood damage reduction plans using risk analysis. Program output includes:
  - Expected annual damage (EAD) and EAD Reduced
  - Equivalent annual damage and equivalent annual damage reduced
  - Project performance based on a target stage such as the top-of-levee (levee certification)

HEC-FDA Input

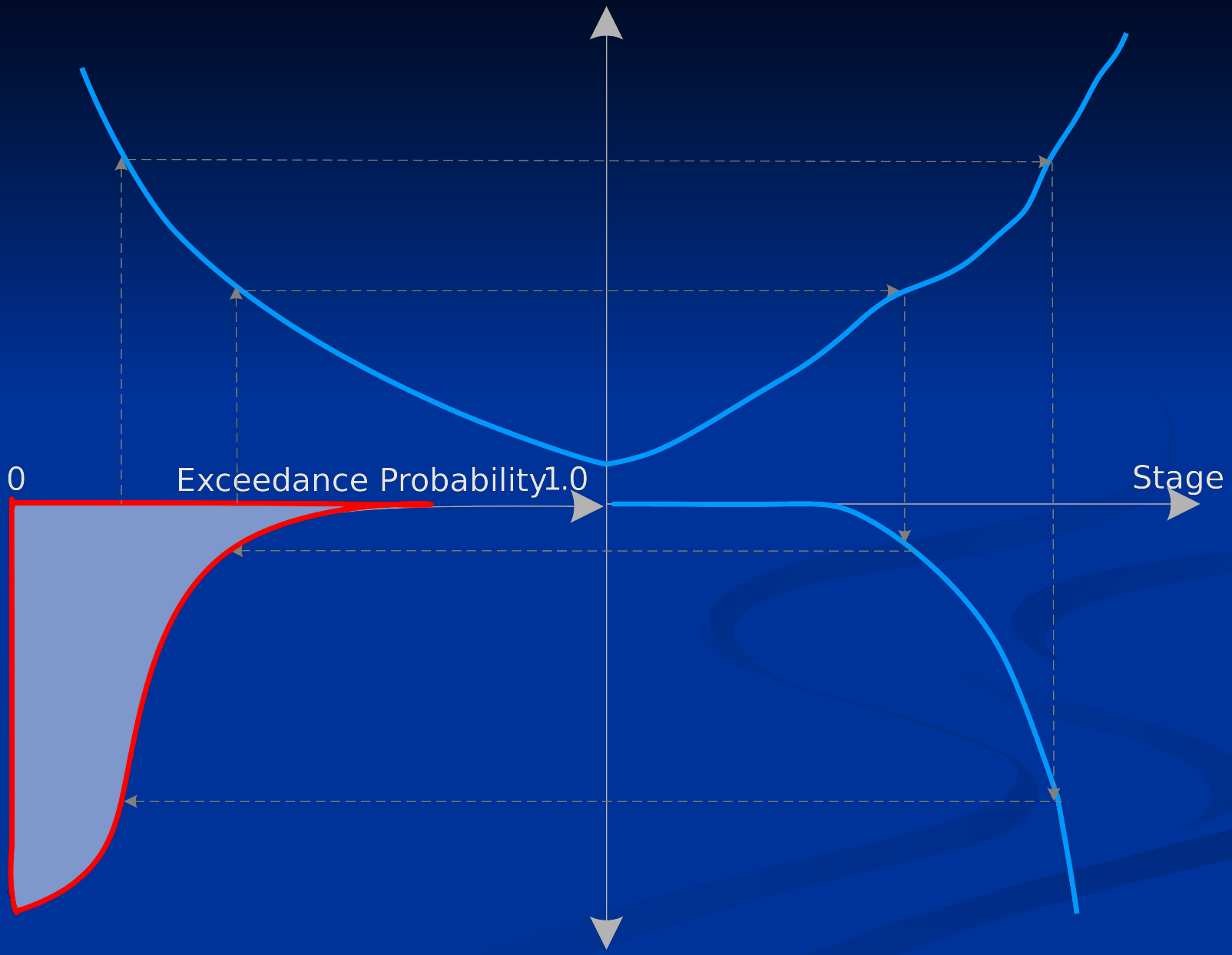
- Hydrology and Hydraulics
  - Annual Peak Probability Function with Uncertainty
    - Stage-Probability
    - Discharge-Probability
  - Transform Flow Function With Uncertainty (regulated probability curves)
  - Stage-Discharge Function With Uncertainty

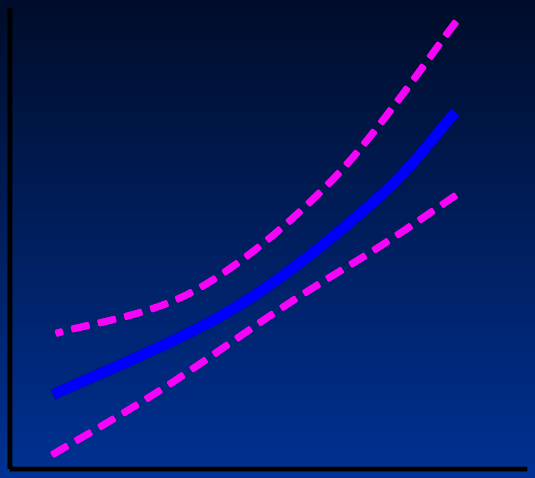
HEC-FDA Input (cont.)

- Levee
  - Top of Levee Stage
  - Geo-Technical Failure Function
  - Exterior vs. Interior Stage Function
  - ~~Wave Run up~~

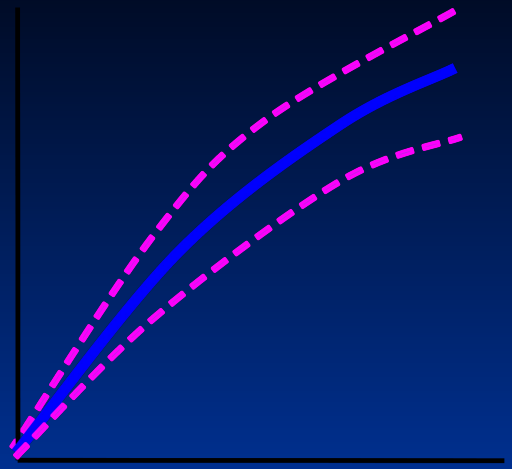
HEC-FDA Output

- Stage-Aggregated Damage
- Expected Annual Damage for base and most likely future years
- Equivalent Annual Damage (expected annual damage discounted and analyzed over the period of analysis)
- Project Performance – Target Stage
  - Expected annual exceedance probability (AEP)
  - Long term risk – probability of exceedance over a period of years such as 30 years
  - Conditional non-exceedance (probability of containing the 1% chance event). Necessary for levee certification.

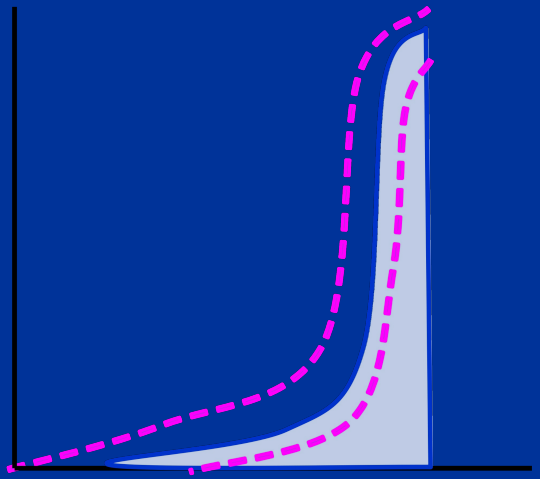

0
Exceedance Probability
1.0
Stage



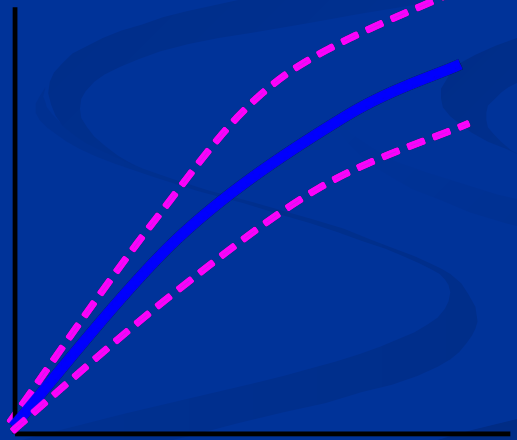
Exceedance Probability



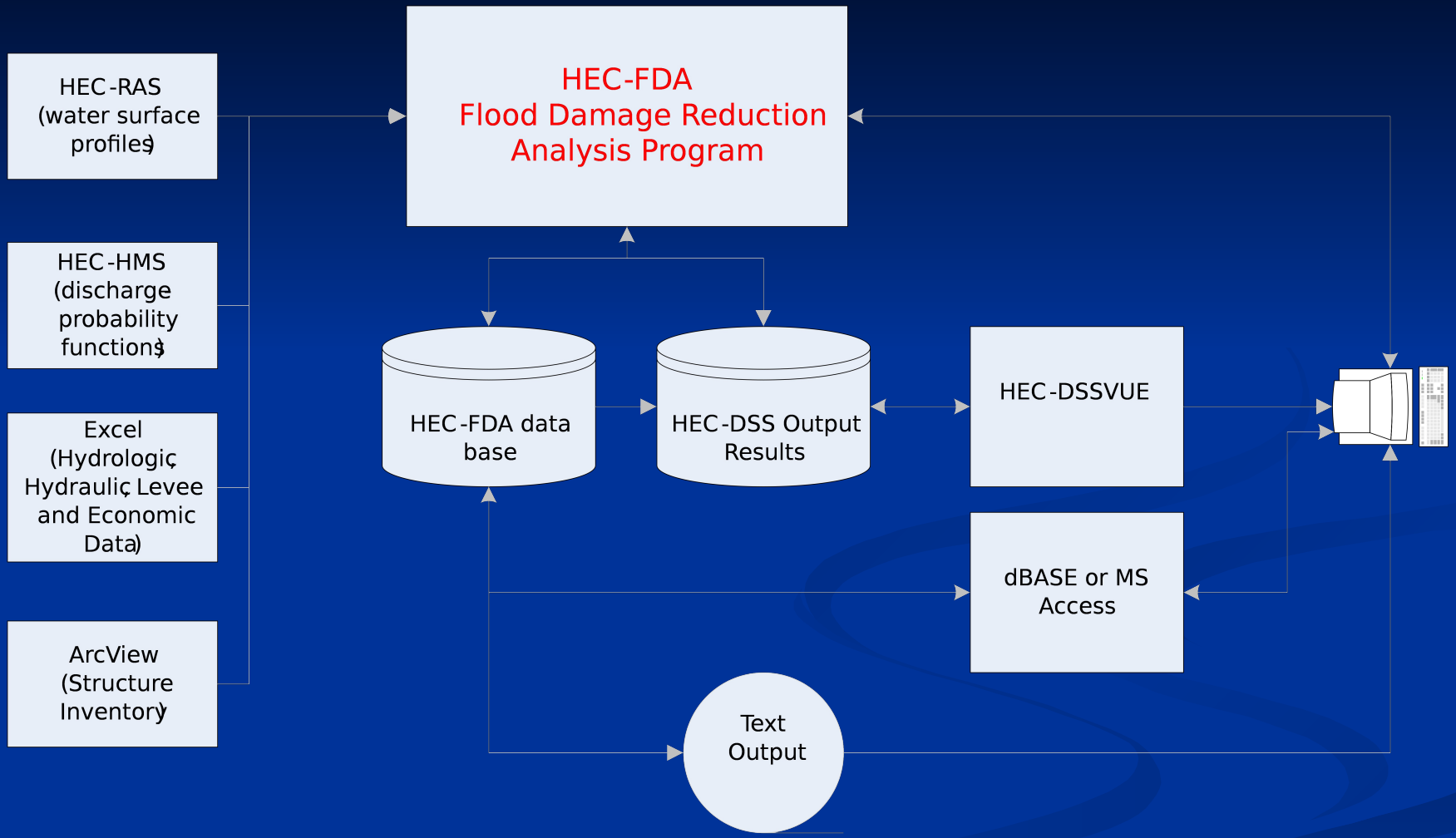
Discharge (cfs)



Exceedance Probability



Elevation (feet)


HEC-FDA
Flood Damage Reduction
Analysis Program
HEC-RAS
(water surface
profiles)
HEC-HMS
(discharge
probability
functions)
Excel
(Hydrologic,
Hydraulic, Levee
and Economic
Data)
ArcView
(Structure
Inventory)
HEC-FDA data
base
HEC-DSS Output
Results
HEC-DSSVUE
dBASE or MS
Access
Text
Output

Version 1.4 Enhancements

- Calculations
- Project Performance Reports
- Input / Output
- Import / Export
- Miscellaneous (e.g. number of damage categories)

V 1.4 Computations

- Uncertainty about graphical probability curves
  - Candidate Methods
    - Order statistics using equivalent length of record in years (current method)
    - Order statistics using 1,000 years, then scaled to the equivalent length of record
    - “Simple” method
  - After a lot of thought and analysis, FDA will use the “simple” method. That means results will change including AEP & Conditional Nonexceedance.

Uncertainty About Graphical Probability Curves

Figure 30 Tuolumne Regulated Discharge-Probability Function, Version 1.2

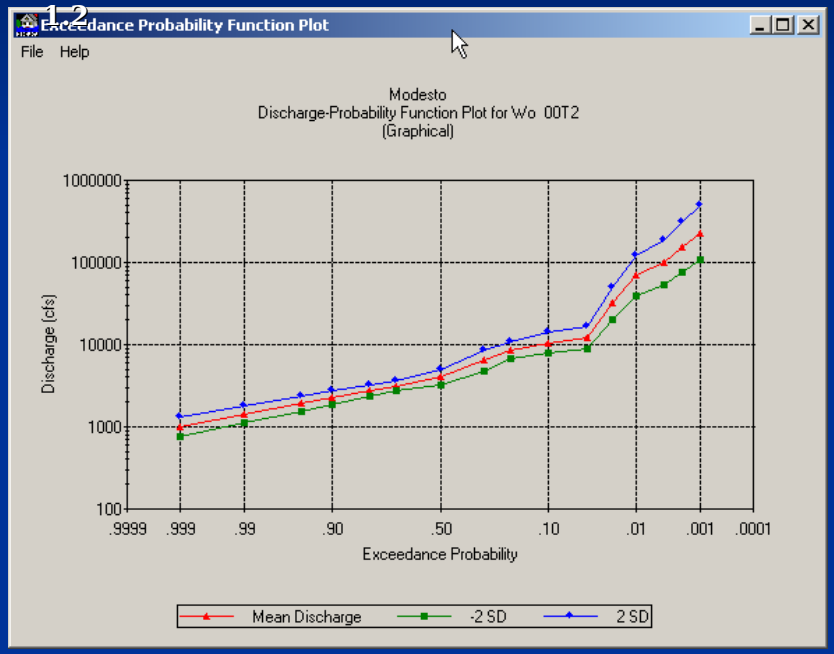
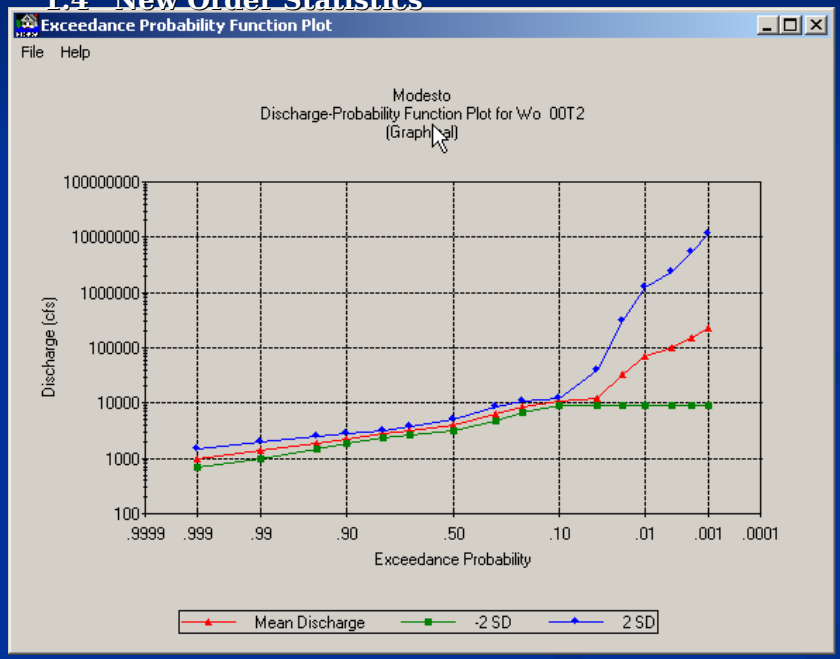
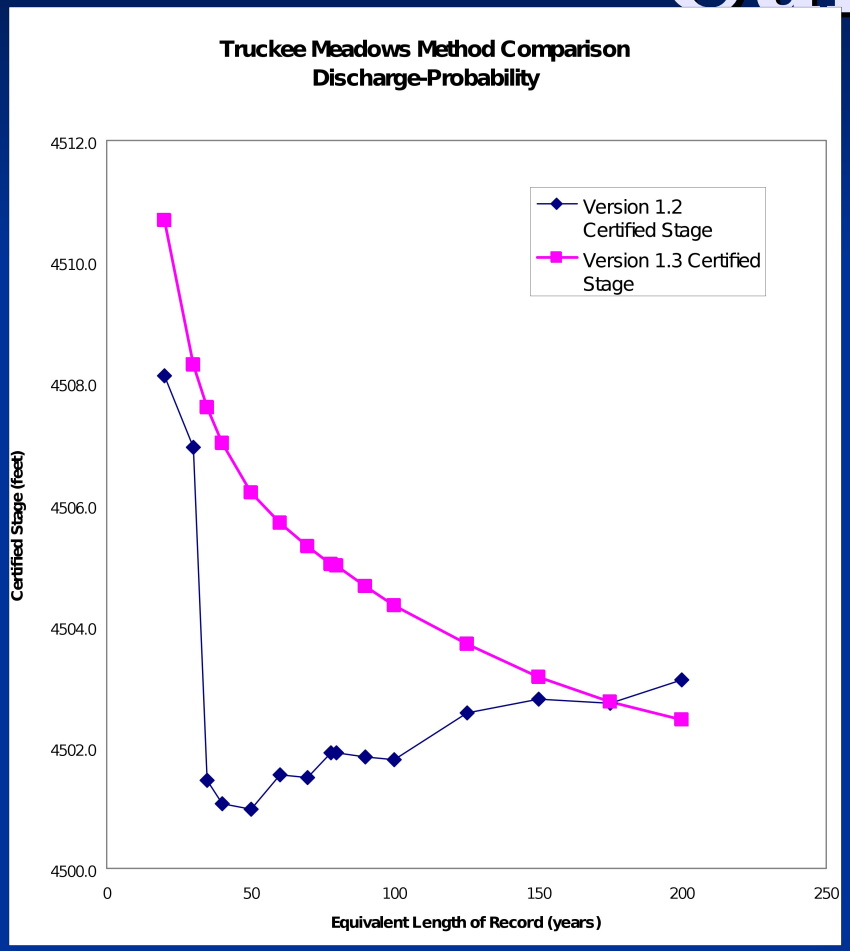
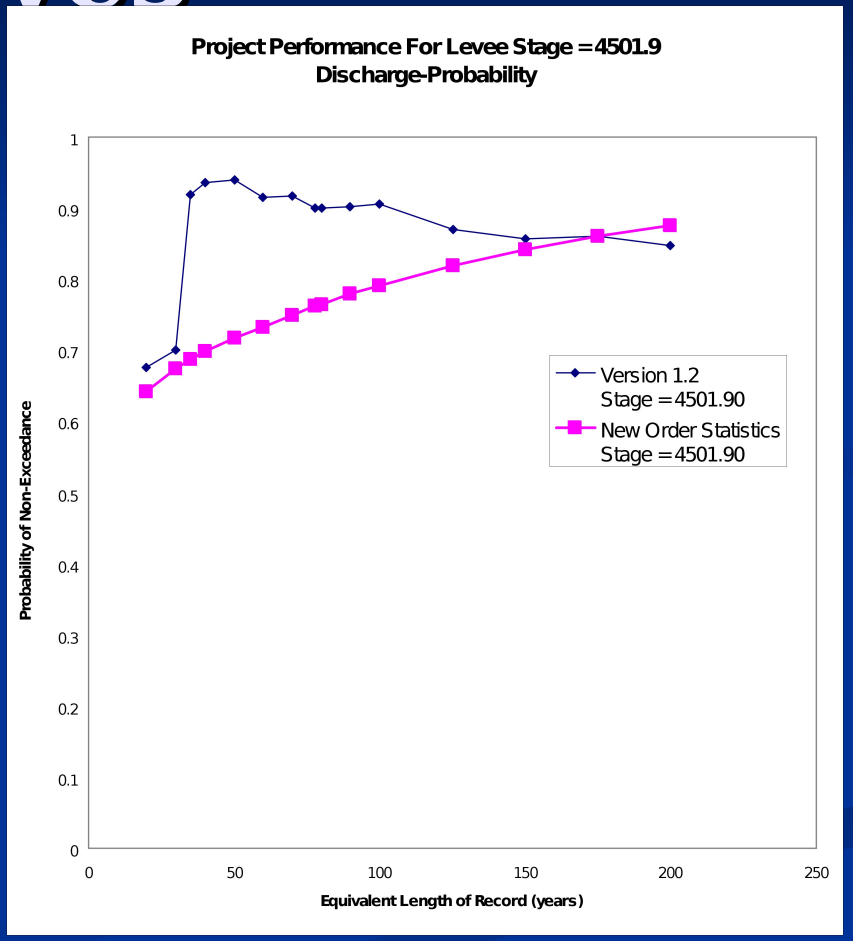


Figure 31 Tuolumne Regulated Discharge-Probability Function, Version 1.4 "New Order Statistics"



Uncertainty About Graphical Probability Curves





V 1.4 Calculations – Levees

- Improvements include:
  - Reaches may now contain both a geotechnical failure function and an exterior-interior stage function
  - Calculations involving geotechnical failure are more accurate – somewhat case dependent
  - Calculation of “average” probability curves is more accurate

“Average” Discharge-Probability

Figure 8 Chester Creek Damage-Probability, Without, Base Year, Version 1.2

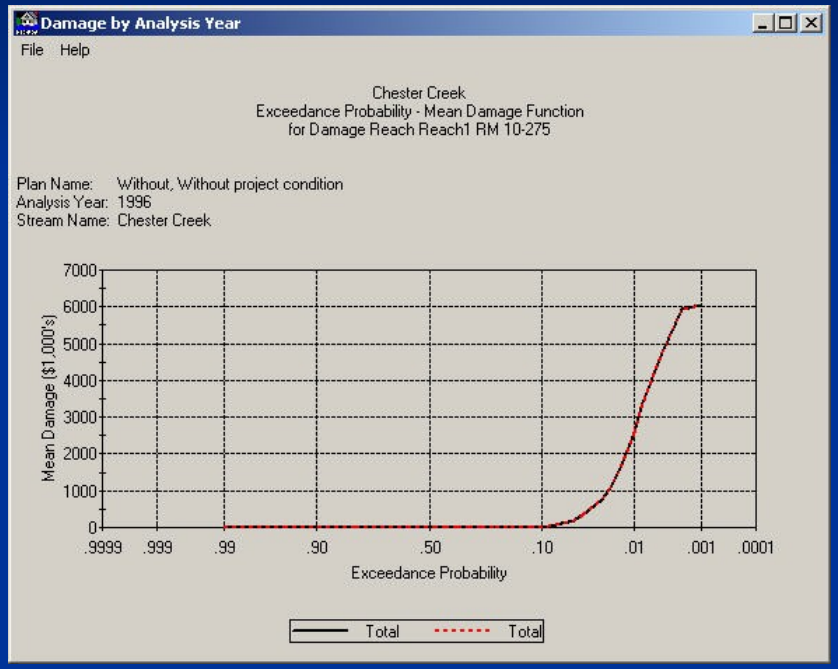
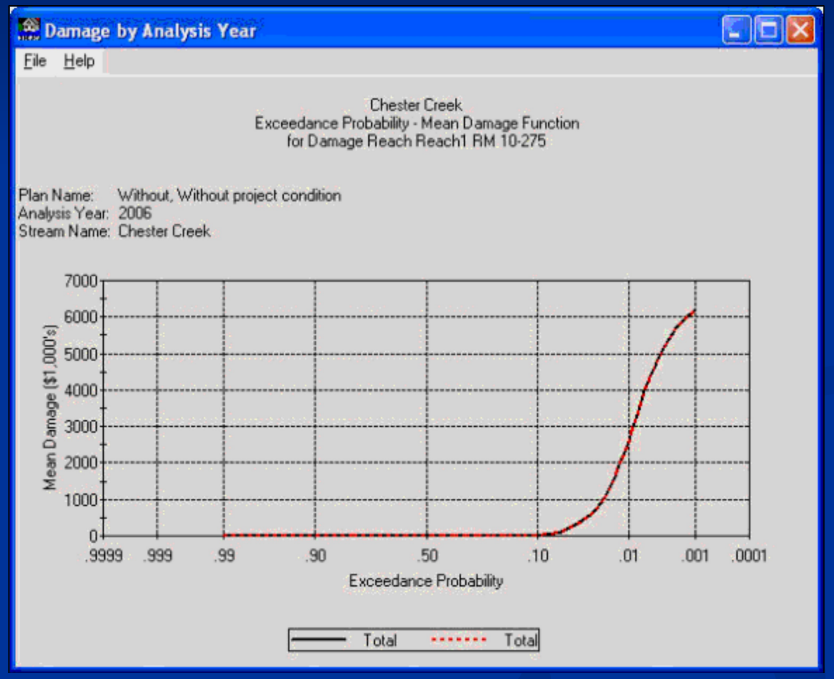


Figure 9 Chester Creek Damage-Probability, Without, Base Year, Version 1.4



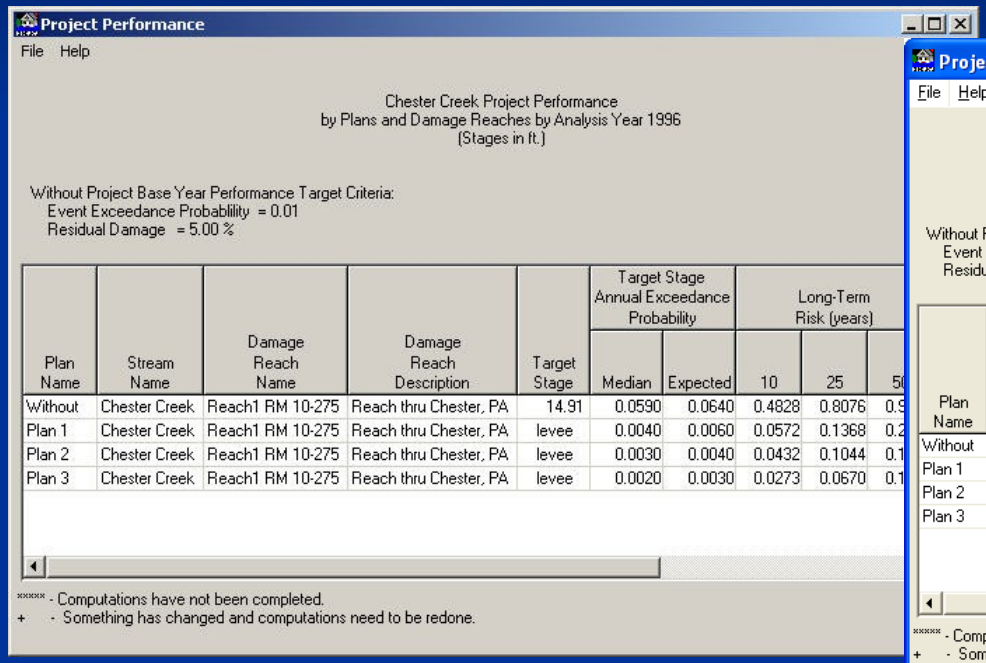
V 1.4 Calculations

- Improvements include:
  - Expected annual exceedance probability has greater accuracy (computed and stored)
  - Long term risk includes a period of 30 years rather than 25
  - For stage-damage calculations:
    - Price index is applied to dollars in depth-dollar damage functions.
    - Accounts for exterior-interior stages when scaling range of stages for aggregated functions.

Project Performance Output

Figure 10 Chester Creek Project Performance, Version 1.2

Figure Chester Creek Project Performance, Version 1.4



Project Performance

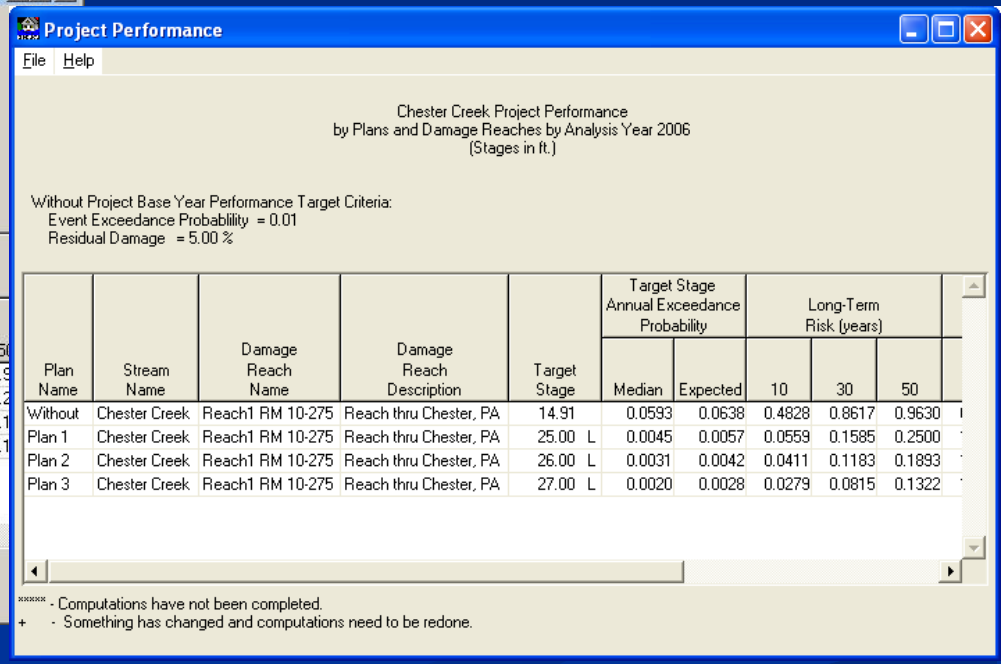
File Help

Chester Creek Project Performance
by Plans and Damage Reaches by Analysis Year 1996
(Stages in ft.)

Without Project Base Year Performance Target Criteria:
Event Exceedance Probablility = 0.01
Residual Damage = 5.00 %

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)		
					Median	Expected	10	25	50
Without	Chester Creek	Reach1 RM 10-275	Reach thru Chester, PA	14.91	0.0590	0.0640	0.4828	0.8076	0.9
Plan 1	Chester Creek	Reach1 RM 10-275	Reach thru Chester, PA	levee	0.0040	0.0060	0.0572	0.1368	0.2
Plan 2	Chester Creek	Reach1 RM 10-275	Reach thru Chester, PA	levee	0.0030	0.0040	0.0432	0.1044	0.1
Plan 3	Chester Creek	Reach1 RM 10-275	Reach thru Chester, PA	levee	0.0020	0.0030	0.0273	0.0670	0.1

***** - Computations have not been completed.
\+ - Something has changed and computations need to be redone.



Project Performance

File Help

Chester Creek Project Performance
by Plans and Damage Reaches by Analysis Year 2006
(Stages in ft.)

Without Project Base Year Performance Target Criteria:
Event Exceedance Probablility = 0.01
Residual Damage = 5.00 %

Plan Name	Stream Name	Damage Reach Name	Damage Reach Description	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)		
					Median	Expected	10	30	50
Without	Chester Creek	Reach1 RM 10-275	Reach thru Chester, PA	14.91	0.0593	0.0638	0.4828	0.8617	0.9630
Plan 1	Chester Creek	Reach1 RM 10-275	Reach thru Chester, PA	25.00 L	0.0045	0.0057	0.0559	0.1585	0.2500
Plan 2	Chester Creek	Reach1 RM 10-275	Reach thru Chester, PA	26.00 L	0.0031	0.0042	0.0411	0.1183	0.1893
Plan 3	Chester Creek	Reach1 RM 10-275	Reach thru Chester, PA	27.00 L	0.0020	0.0028	0.0279	0.0815	0.1322

***** - Computations have not been completed.
\+ - Something has changed and computations need to be redone.

V 1.4 Changes

- Miscellaneous changes
  - Number of damage categories is increased to 20
  - The base and most likely future years can be changed
  - The units can be changed (labels only)

V 1.4 Import / Export

- All input data can be imported and exported using delimited text files (e.g. tab delimited text files from Excel)
  - Economics (v1.2)
  - Water Surface Profiles (v1.2 but not documented)
  - Probability Functions (v1.4)
  - Stage-Discharge Rating Curves (v1.4)
  - Levee data (v1.4)
  - Stage-Aggregated Damage Functions (future version)

Import / Export
H&H

Freq_Name		Plan		Year		Stream		Reach		Yrs		FFtype		DataType		Desc
FR-7 PRE		Without		2001		Feather River		FDR4		84		G		S		Stage-frequ
		PROB	0.99999	0.5	0.2	0.1	0.04	0.02	0.01	0.004	0.002					
		STAGE	38	45	50.8	52.4	58.8	59.9	60.77	66.85	71.04					
Levee_Name		Plan		Year		Stream		Reach		ElTop		Desc				
RB L. Feather		Without		2001		Feather River		FDR4		65.8		Right bank Feather River below Yuba, above Bear River				
		SE	19	42.99	43	115										
		SI	39.99	40	43	115										
		GSE	43	62	64	65.8										
		GPF	0	0.15	0.85	1										

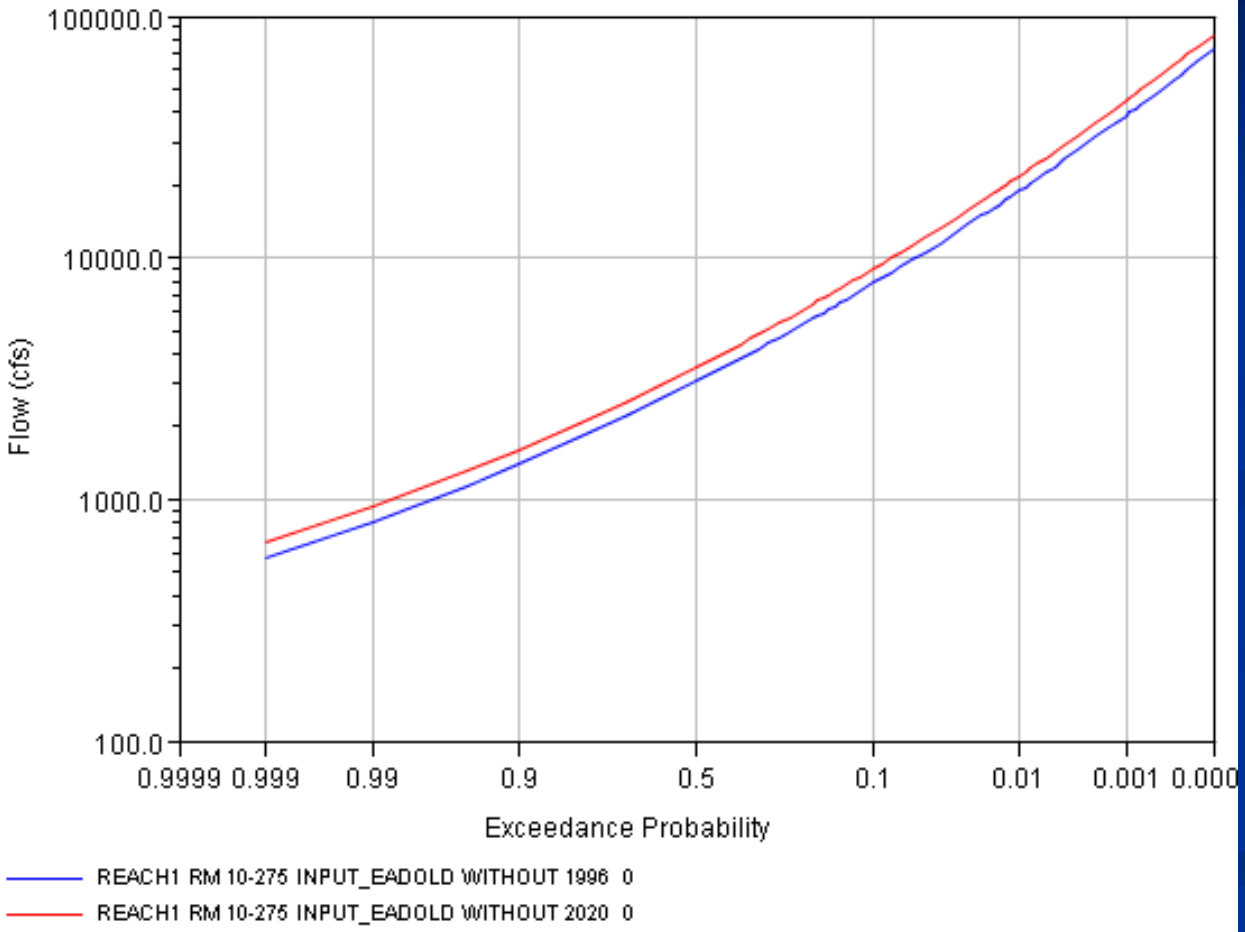
WSP_Name	Description	Plan		Year		Stream		Type		Notes
FEATHER PRE	F	Without		2001		Feather River		STAGE_FREQUENCY		
WSP_Probability										
	0.5	0.2	0.1	0.04	0.02	0.01	0.004	0.002		
WSP_Station	Invert	Stage	Stage	Stage	Stage	Stage	Stage	Stage	Stage	
12.5	15.2	45	50.8	52.4	58.8	59.9	60.77	66.85	71.04	
17	19	45	50.8	52.4	58.8	59.9	60.77	66.85	71.04	
27.6	27.95	55	60.9	62.6	73	74.2	74.81	81.53	86.17	
28.85	29	55	60.9	62.6	73	74.2	74.81	81.53	86.17	
30.25	30.49	55	60.9	62.6	73	74.2	74.81	81.53	86.17	
37.25	40	59.3	65.2	66.9	77.3	78.5	79.1	86.3	91	
44.25	45.35	59.3	65.2	66.9	77.3	78.5	79.1	86.3	91	

V 1.4 Output

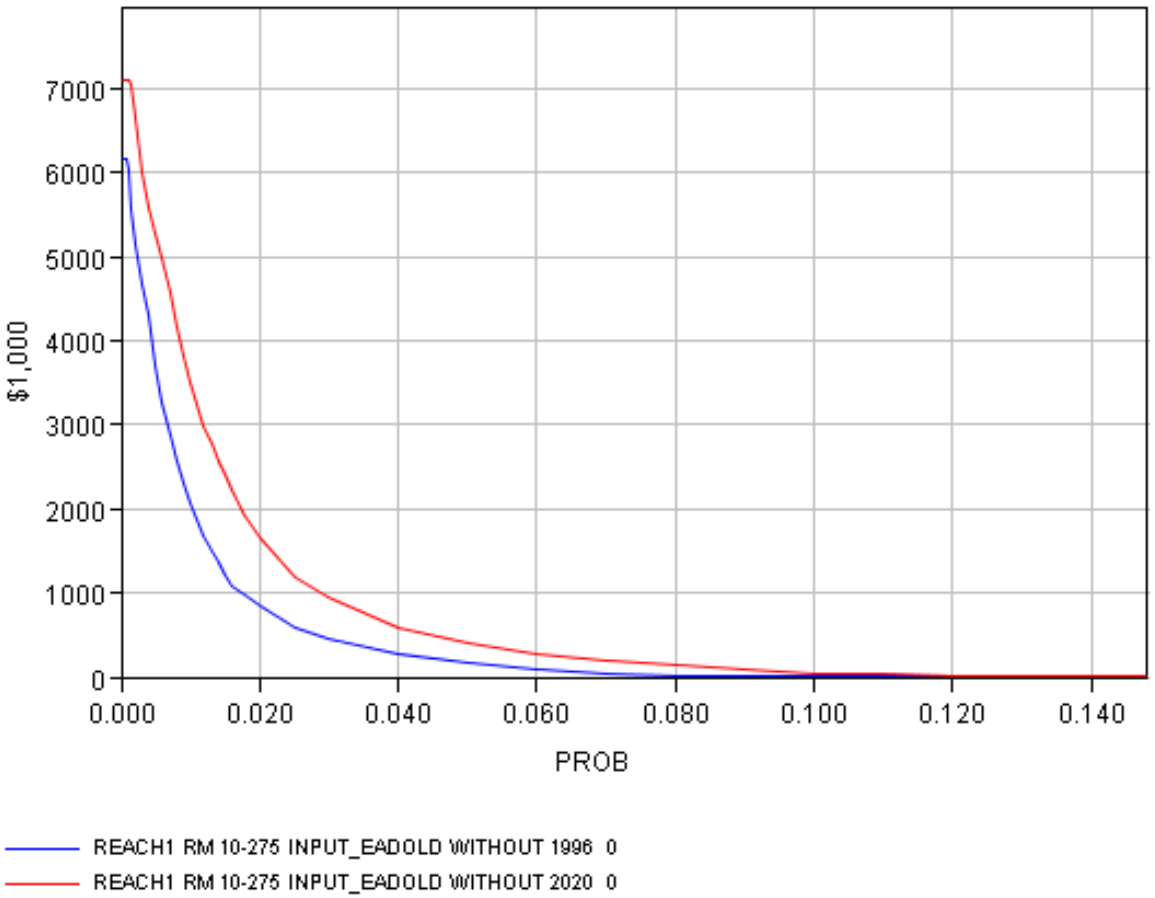
- HEC-DSS data file (not relational)
  - Written at EAD computation time by plan/year/reach
    - Input Data
      - Discharge-Probability
      - Stage-Discharge
      - Stage-Damage by Category and Total
      - Derived Functions
        - Stage-Probability
        - Damage-Probability
    - Output
      - Average probability functions
      - Top ten, bottom ten, and “wishy-washy” ten functions
      - Distribution of EAD and AEP
      - Conditional Non-Exceedance Probabilities

Input Functions in HEC-DSS

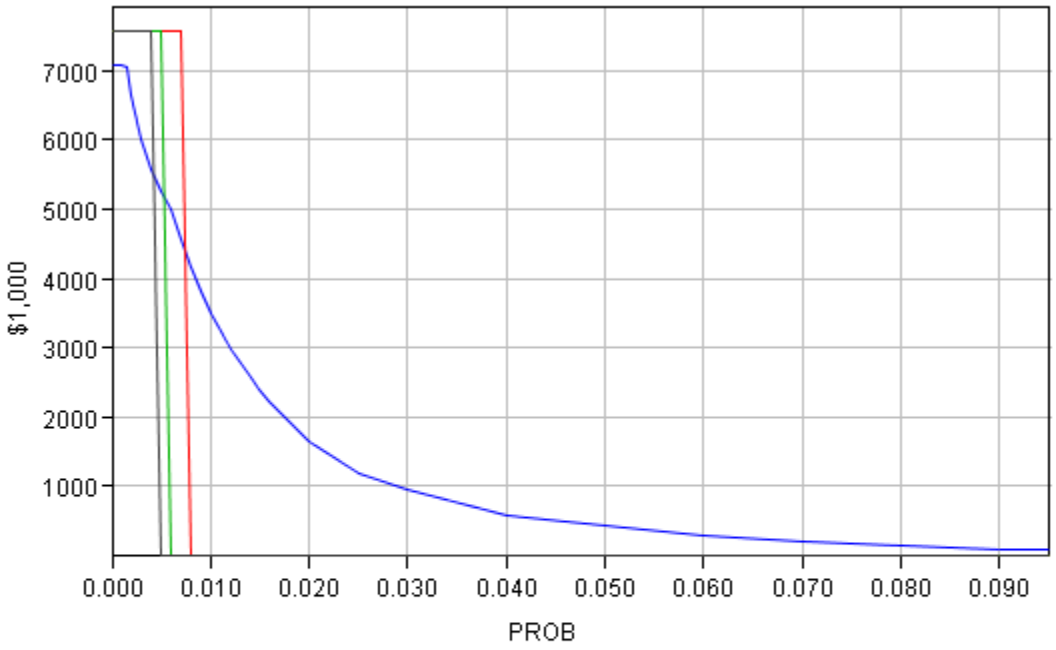
Displayed Using HEC-DSSVUE



Derived Functions in HEC-DSS – Damage-Probability for Without

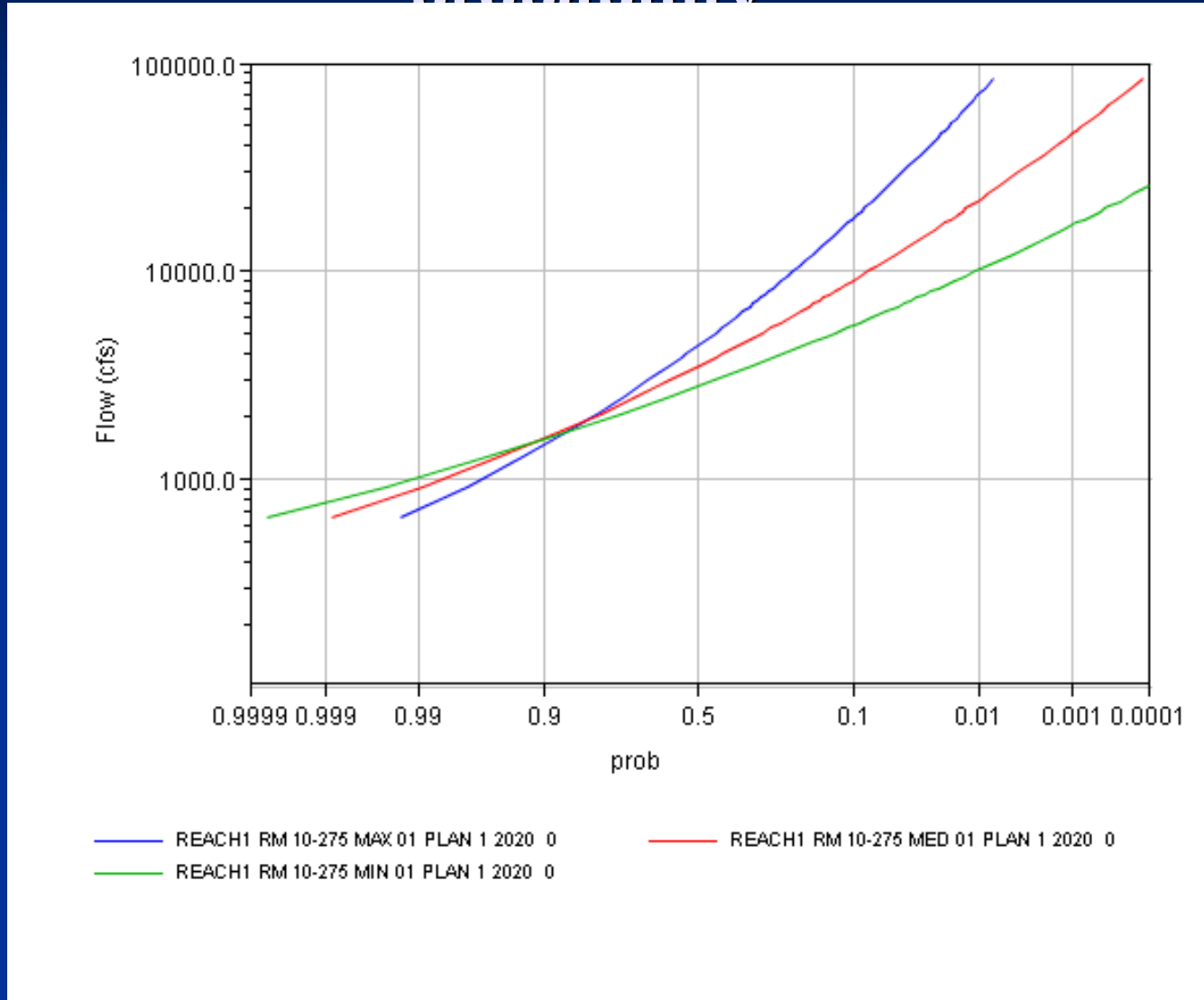


Derived Functions in HEC-DSS – Damage-Probability by Plan

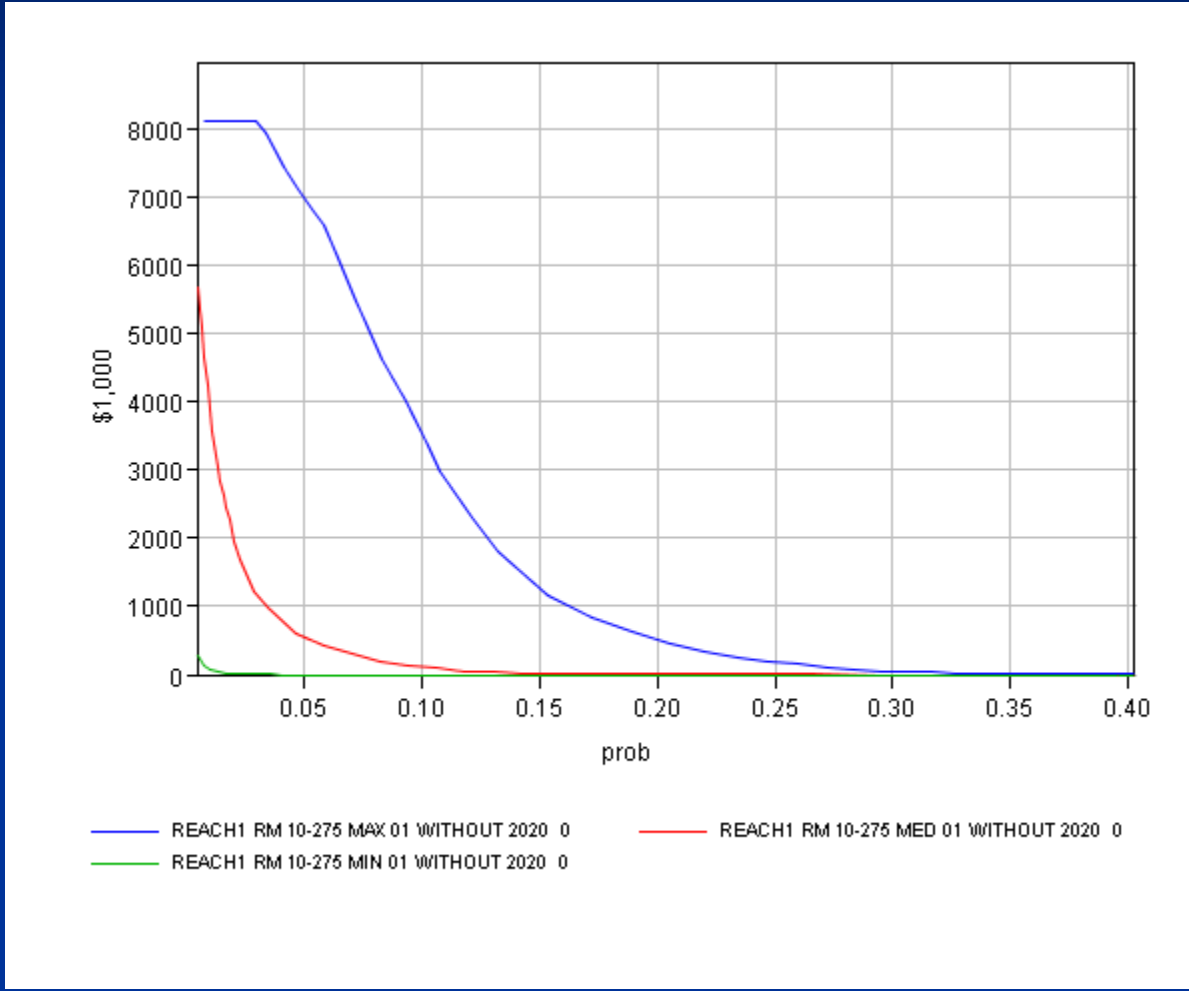


Replicates (Top Ten)

Actually 20; This Example represent the highest, lowest, and “middle” discharge-probability

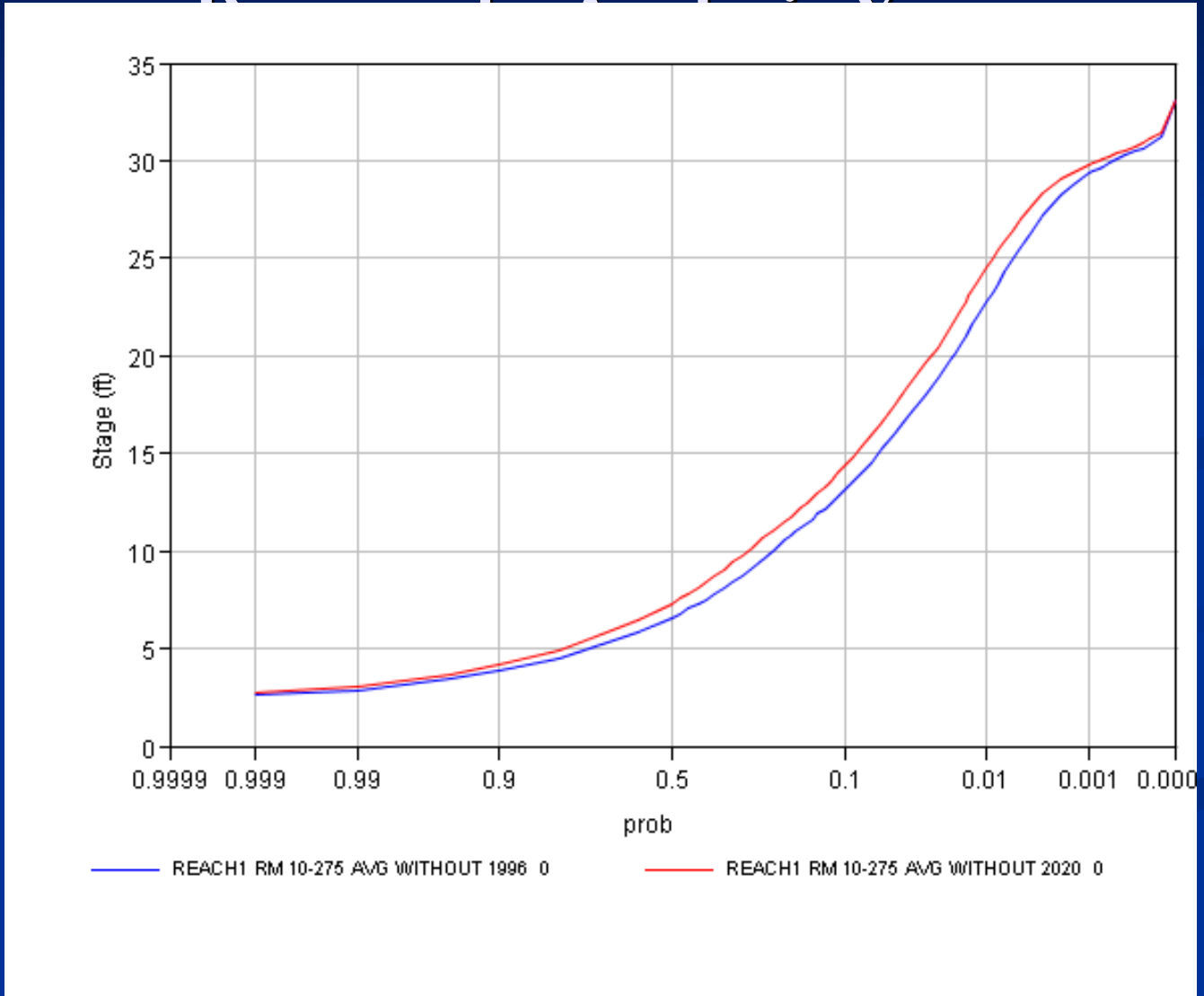


Replicates (“Top Ten”)
Damage-Probability



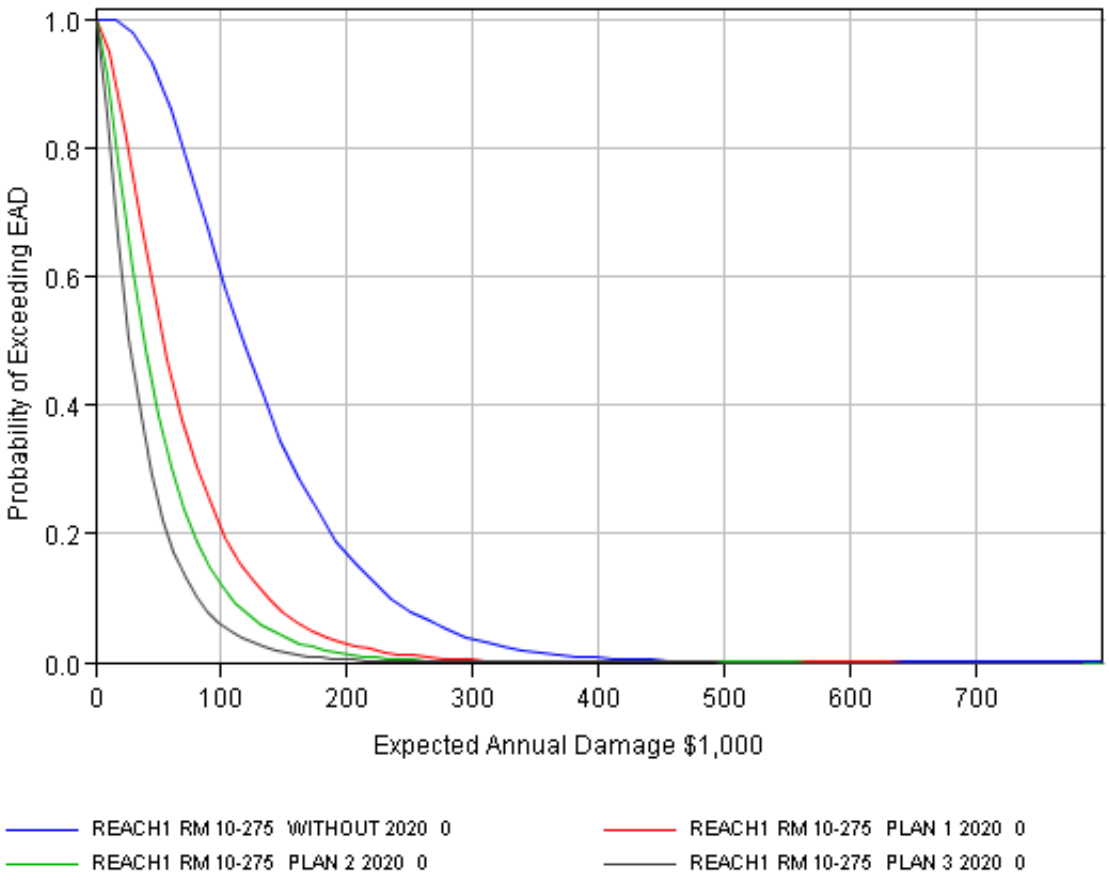
“Average” Probability Functions

In HEC-FDA, view under Evaluation / Results /

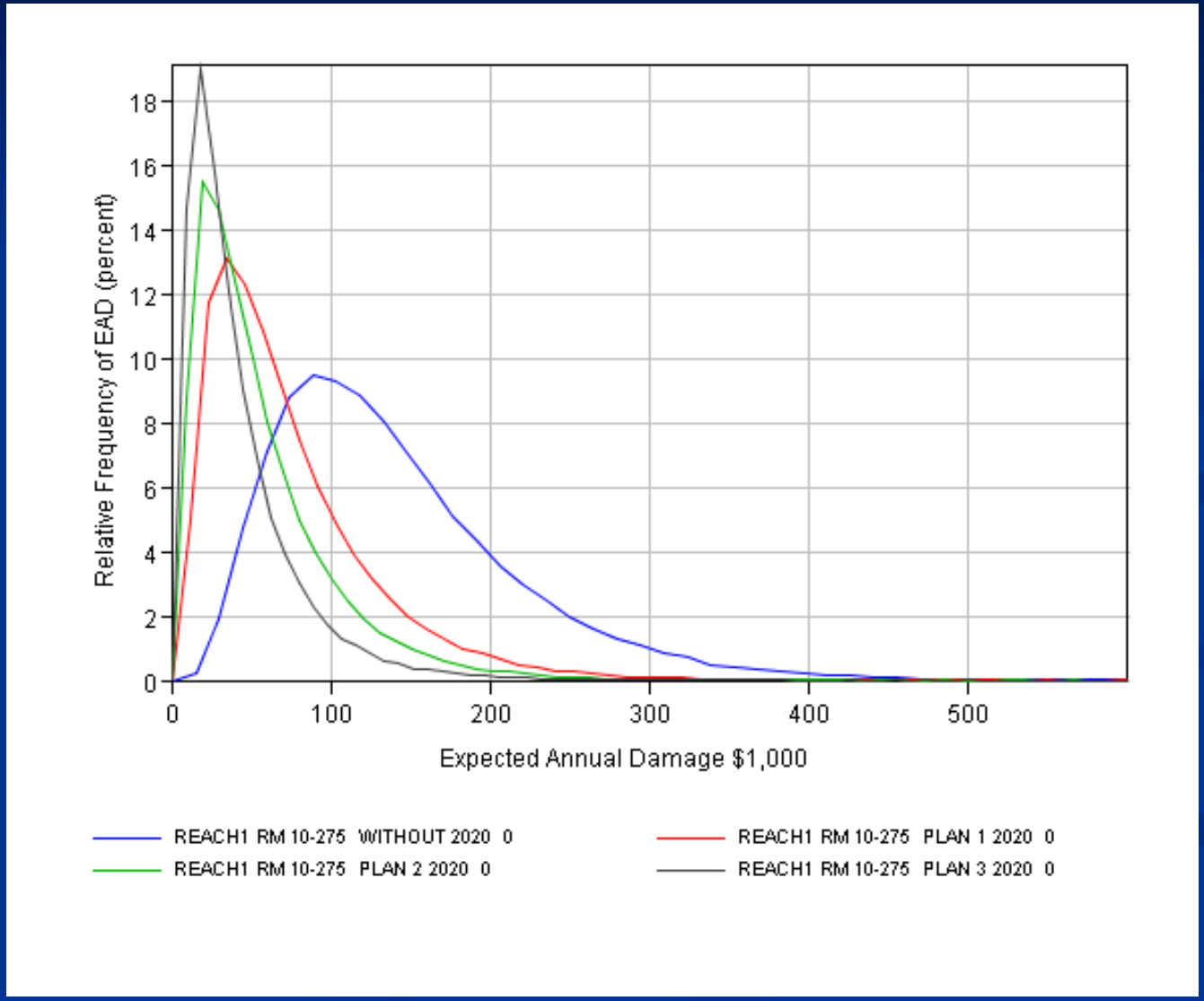


Distribution of EAD from HEC-DSS

The probability that EAD exceeds a given value

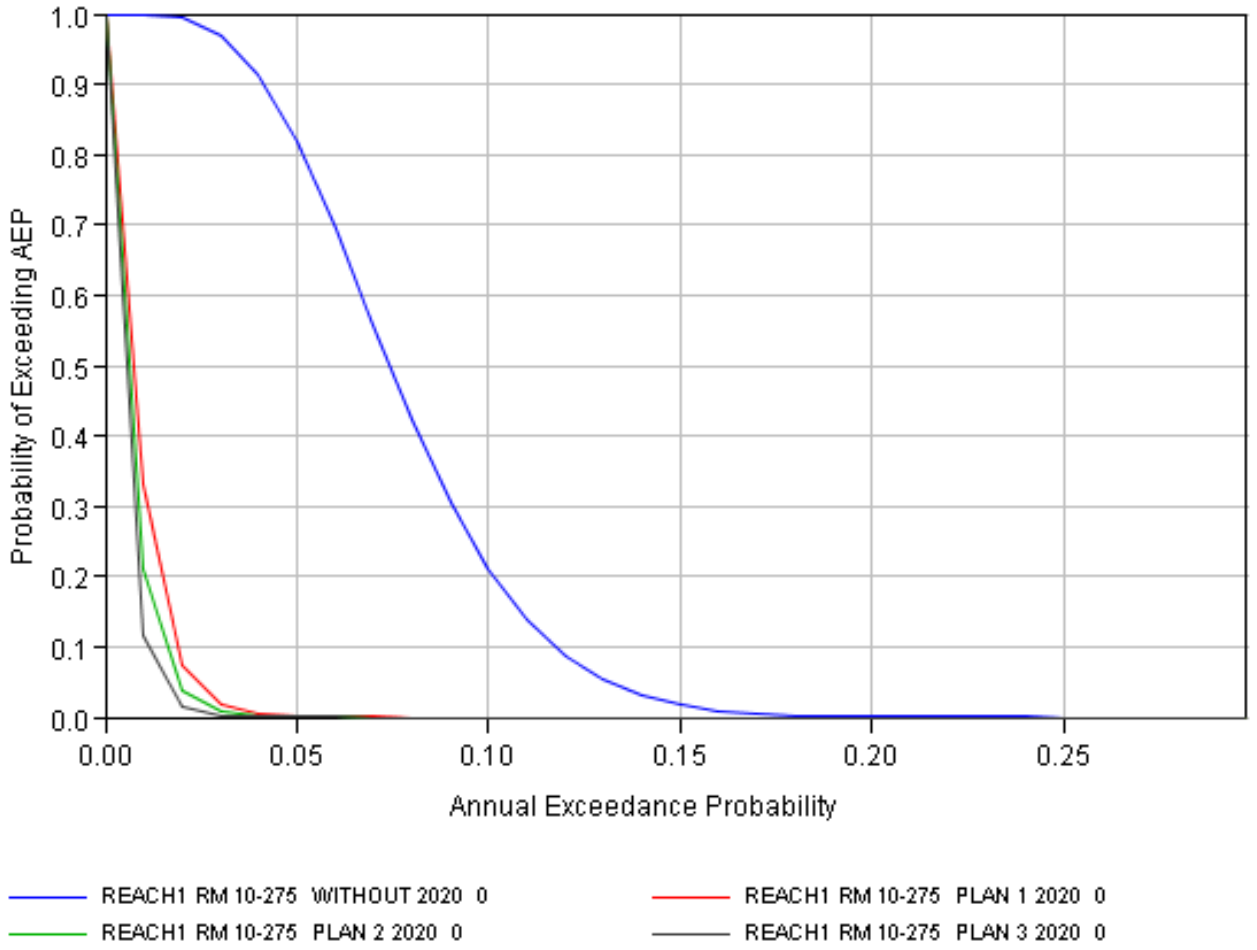


EAD – Relative Frequency from HEC-DSS

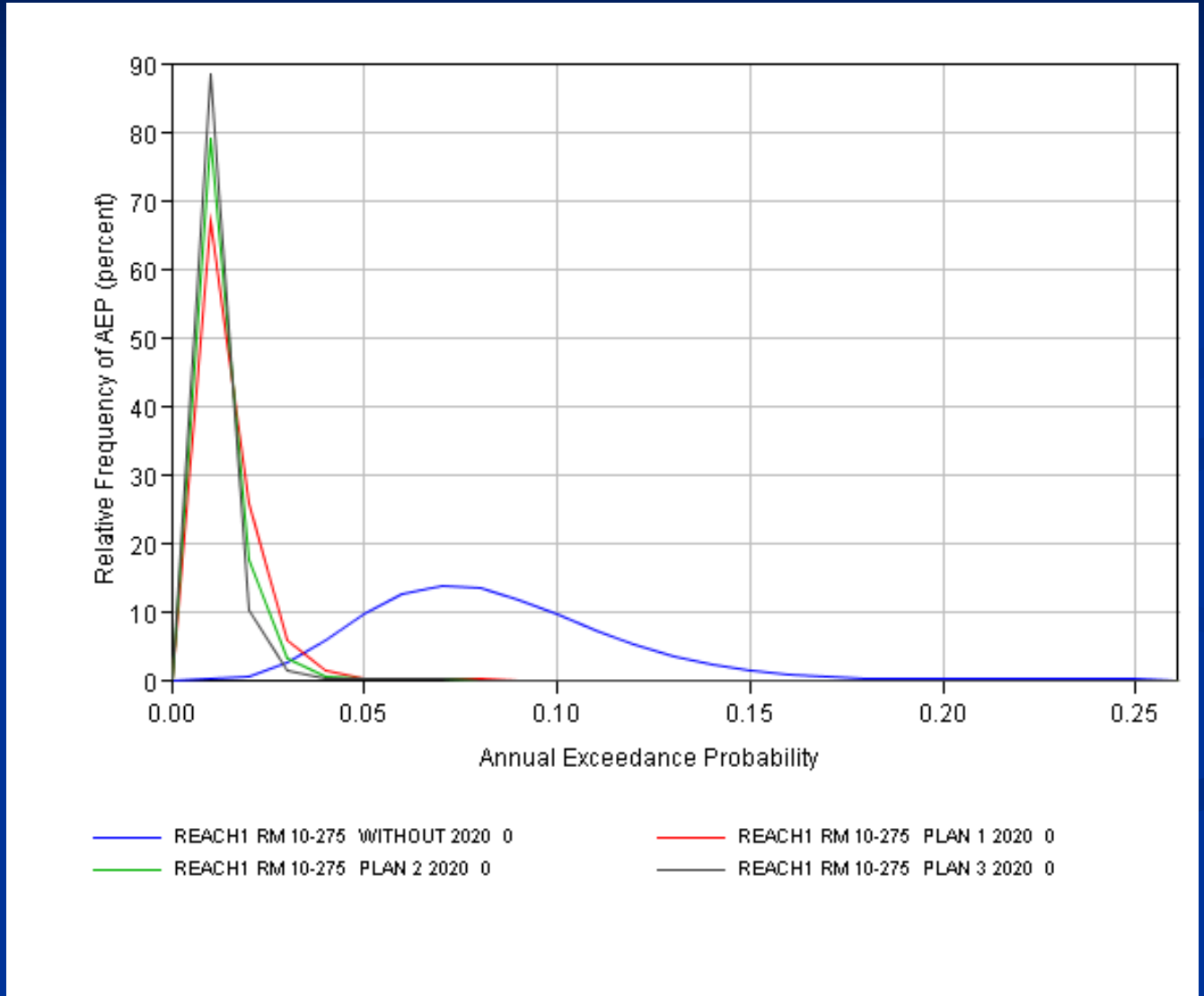


Distribution of AEP from HEC-DSS

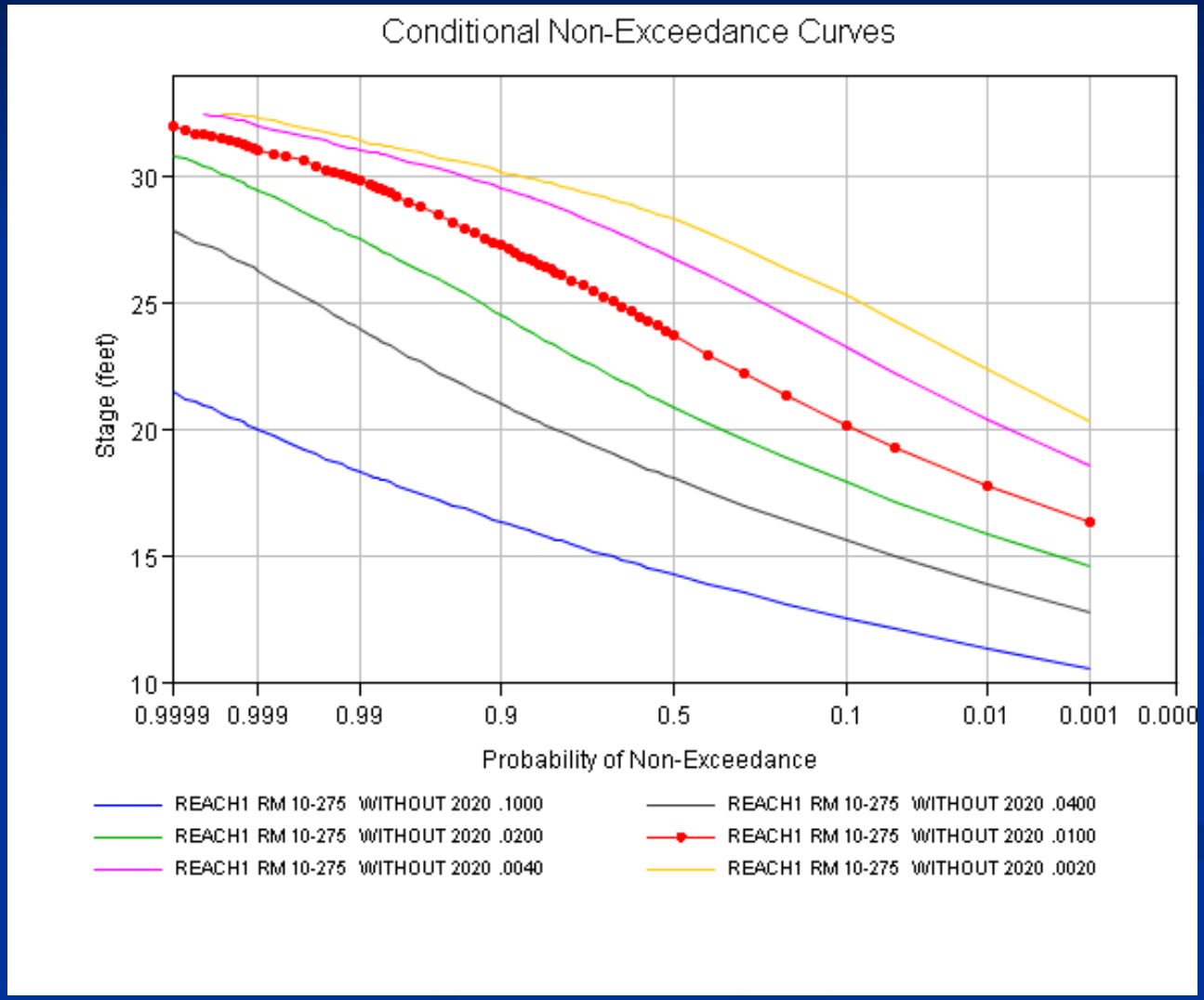
The probability that the AEP exceeds a given



AEP – Relative Frequency from HEC-DSS



Conditional Non-Exceedance Probability



V 1.4 Output (cont..)

- Program Output
  - Project Performance tables include levee stage and flag for levee / geotechnical
  - Long term risk for 30 years
  - All Evaluation / Results output tables are written to screen and text output file

Project Performance Output

Project Performance

File Help

Chester Creek Project Performance
by Plans and Damage Reaches by Analysis Year 2020
(Stages in ft.)

Without Project Base Year Performance Target Criteria:
Event Exceedance Probablility = 0.01
Residual Damage = 5.00 %

Plan Name	Stream Name	DRN	DRD	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events					
					Median	Expected	10	30	50	10%	4%	2%	1%	.4%	.2%
Without	Chester Creek	R	R	15.48	0.0721	0.0773	0.5526	0.9105	0.9821	0.7886	0.0870	0.0049	0.0001	0.0000	0.0000
Plan 1	Chester Creek	R	R	25.00 L	0.0070	0.0089	0.0859	0.2362	0.3618	1.0000	0.9961	0.9160	0.6585	0.2381	0.0771
Plan 2	Chester Creek	R	R	26.00 L	0.0050	0.0068	0.0660	0.1852	0.2892	1.0000	0.9983	0.9609	0.7747	0.3568	0.1407
Plan 3	Chester Creek	R	R	27.00 L	0.0040	0.0049	0.0483	0.1381	0.2194	1.0000	0.9996	0.9831	0.8695	0.5227	0.2563

***** - Computations have not been completed.
\+ - Something has changed and computations need to be redone.

Report Project Performance by Plans and Reaches.																
Study:	Chester Creek															
Year:	#															
Units:	ft.															
					Target Stage Annual Exceedance Probability		Long-Term Risk (years)			Conditional Non-Exceedance Probability by Events						
Stream Name	Reach Description	Reach Description	Target Station	Tech	Median	Expected	10	30	50	0.1	0.04	0.02	0.01	0.004	0.002	
Without	Chester Creek RM 10-275	Reach 1 thru 15	15.48	Chester, PA	0.0721	0.0773	0.5526	0.9105	0.9821	0.7886	0.087	0.0049	0.0001	0	0	
Plan 1	Chester Creek RM 10-275	Reach thru 25		Chester, PA	0.007	0.0089	0.0859	0.2362	0.3618	1	0.9961	0.916	0.6585	0.2381	0.0771	
Plan 2	Chester Creek RM 10-275	Reach thru 26		Chester, PA	0.005	0.0068	0.066	0.1852	0.2892	1	0.9983	0.9609	0.7747	0.3568	0.1407	
Plan 3	Chester Creek RM 10-275	Reach thru 27		Chester, PA	0.004	0.0049	0.0483	0.1381	0.2194	1	0.9996	0.9831	0.8695	0.5227	0.2563	

Status

- Currently Distributed: Version 1.2, March 2000
- Next Release: Version 1.4 later this FY. Many changes, but interface virtually the same.
- Down the Road: Version 2.0 alpha beginning of FY 09. New interface similar to HEC-FIA, calculations the same as version 1.4.